Task Engagement vs. Driving Performance: The Effects of Secondary Task

Final Rough Draft Assignment

LAEM Transportation

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Abstract

The objective of this study is to measure and determine which secondary task incurs higher task-engagement while driving. Participants included 30 undergraduate students from Old Dominion University ranging in age from 18 to 64 years old. Participants volunteered through the SONA system and were required to have a valid driver's license for two years. A within-subjects ANOVA design was utilized to examine the secondary tasks which are texting, talking, watching Tik Tok videos, and mind wandering. The study uses the MAT-C system, a driving simulator, to determine driving performance of the secondary tasks. At the end of the session each participant completed an engagement questionnaire, scoring their level of engagement. The results found viewing TikTok required participants to be more engaged and impacted driving variability. Further research regarding TikTok impact on distracted driving is needed to verify an explanation and replicate these findings.

Keywords: distracted driving, engagement, in-vehicle tasks, secondary tasks

Task Engagement vs. Driving Performance: The Effects of Secondary Tasks

Distracted drivers are individuals engaging in risky behavior, whose attention is divided between a primary and secondary task. Driving requires individuals to sustain both cognitive and spatial awareness, but also manual control of the vehicle (Li et al., 2021). The study aims to compare four secondary task variables (e.g., texting, talking, watching Tik Tok videos, and mind wandering) and the effects it has on driver performance. Matthews et al. (2002) suggest affect, motivation, and cognition are three areas of psychological functions that serve as interconnected task engagement processes. Multi-tasking behavior requires competing psychological functions (e.g., information processing and attention) diverting drivers' ability to operate a motor vehicle. Texting while driving causes a reduction in traffic safety (Li et al., 2021). Engaging in secondary tasks increases the likelihood of drivers being involved in a motor vehicle accident. Distracted driving is a risky behavior where a driver can divert their attention onto a secondary task. However, there are consequences for distracted driving. In 2018, the CDC estimated in the U.S., eight people are killed per day in accidents that involved a distracted driver (CDC, 2021). Distracted driving poses a safety hazard to all who share the road (e.g., pedestrians and motorists). Populations prone to fatal accidents involving distracted driving are teenagers and young adults (CDC, 2021). Distracted driving has steadily produced more deaths than those of intoxicated driving, failure to use seatbelts, and speeding (Tran et al., 2018). Shi et al. (2019) describes two types of distractions, external and internal. External distractions occur outside the vehicle (e.g., crossing animals and other drivers). Internal distractions occur inside the vehicle (e.g., eating, texting, and thinking). The purpose of the study is to compare task engagement effects on driving performance while engaging in a secondary task. Task engagement occurs when drivers shift attention onto a secondary task.

O'Brien and Tom's (2008) model of engagement describes individuals cycling through three levels of technological engagement: a) initial b) sustained c) disengagement. A driver's perception of devices being interesting, user friendly, and stimulating can explain how drivers sustain engagement. Distracted drivers cycle through each level numerous times before discontinuing the behavior.

Theories of dual-task performance state that there is a decrease in performance when two tasks simultaneously occur resulting in a deficit of one or both tasks (Wickens, 2002, as cited in He et al., 2015). A study conducted by He et al. (2015) indicates driving affected texting and vice versa. Results of the study found more lane deviations due to the texting's impact on driving performance. Driving impacts texting by increasing spelling errors, typing mistakes, and completion of writing a message. Drivers engaging in a difficult secondary task allocate more cognitive resources to the secondary task than the primary task (Metz et al., 2014).

Distracted driving is a self-imposed risk taken to complete a secondary task. Previous research on distracted driving concluded that in-vehicle distractions have a greater impact on driving performance than external distractions (Kotaxi et al., 2019). Driving is a complex interplay between visual attention, processing information, and vehicle control. Multiple resource theory proposes engaging in two tasks that involve the same resource (e.g., visual attention) interfere with successfully completing the primary task (i.e., driving) (Kaber et al., 2012). Drivers who allocate their visual attention from the roadways to a screen while texting are unable to process the changing environment.

Theory of Planned Behavior proposes a driver's intentions affect behaviors and are derived from attitudes, societal norms, and perceived behavior control that may influence distracted driving (Chen et al., 2014). Drivers' attitudes are motivated by the outcome of engaging in the desired behavior. Societal norms are written or unwritten rules of society that are perceived as acceptable. Perceived behavior control refers to motorist belief in completing a behavior. Society viewing distracted driving as a "norm" makes drivers overestimate their ability to successfully multitask while driving.

Distracted driving does not always result in motor accidents. Operant conditioning may shed light on a driver's willingness to engage in risky behavior. Engaging in distracted driving is reinforced by the lack of consequences for their behavior. Therefore, drivers will unconsciously engage in distracted behavior out of habit (Bayer & Campbell, 2012). Feldman et al. (2011) research on mindfulness and distracted driving found young drivers will respond to text quicky to stay connected with others to avoid negative emotions.

Individuals' dependency on cellphones has given rise to higher rates of texting and driving (Lansdown, 2009). In 2018, it was estimated 420,000 injuries and 2,800 deaths occurred due to distracted motorists (NHTSA, 2020). Motorists shift attention away from the road onto secondary tasks of interest, leading to negative impacts on driving performance due to limited attention on the primary task (Horrey et al., 2017). Previous research in shifting attention suggests driving while using a cellphone limits driver attention. Driving distracted causes inattention to the primary tasks of driving (i.e., steering, accelerating, decelerating, and reaction time) which makes it more prevalent for car accidents (Klauer et al., 2006). The prevalence of risk, injury, accidents, and death makes texting a high-risk task-engagement.

The Road Traffic Safety Association of China (2018) estimates 50% of drivers, 18-34 years old, use cellphones when driving while being conscious of the risks. Driver-cellphone use makes it four times more likely of being involved in an accident (Klauer et al., 2014). Using a cell phone to dial is less of a risk when compared with texting by novice and inexperienced drivers (Klauer et al., 2014). Driver distractions, specifically texting, can cause a 4.6 second delay due to the driver's inattention to the roadway (Tran et al., 2018). A driver's visual, manual, and cognitive engagement with a secondary task (i.e., texting) can delay response time to the road by 0.6 seconds.

Limitations found in existing research include participant samples which are limited to both small sizes and age groups. Simulator studies limit participants to a controlled environment and do not account for the change in humans' natural behavior. The research focused on fatalities and injuries, not including unharmed distracted drivers. The data from the studies limit researchers to gain a complete model of the effect distracted drivers have in real-life situations.

The purpose of the present study is to determine which secondary task requires more task engagement and has a greater impact on driving variability. Previous research concluded that drivers who texted while driving had a delayed reaction time to abrupt braking and a higher likelihood of being involved in an accident (Drews et al., 2009, as cited in Burge & Chaparro, 2012). He et al. (2015) suggests cellphone use and lane change task interfere with safe driving causing a hindrance to driving performance by causing motorists to deviate from their lane. Burge and Chaparro's (2012) experiment utilizing driving simulator found participants who engaged in typing and restructuring words responded slower to hazardous road conditions.

The authors first hypothesized that texting while driving, under the MAT-C simulation on driving performance, would have a considerable impact on driving variability (e.g., speed and steering control) than the other secondary tasks tested in the experiment. To address engagement, the authors hypothesized participant's score on texting and driving would require higher engagement than the other secondary tasks.

The present study utilizes a driving simulator to determine which secondary task requires more attentional resources. To explore the effects of distracted driving on performance and engagement, four in-vehicle tasks were used (texting, talking, watching TikTok videos, and mind wandering). Participants were given a questionnaire to rate their level of engagement, ranking from 1 (*not at all engaged*) to 7 (*completely engaged*).

Method

Participants

Thirty undergraduate students at Old Dominion University, ages ranging from 18 to 64, participated in the study (20 females, 10 males, M_{age} = 39.7, SD = 15.04). Participants volunteered through SONA System in this experiment and were compensated 10 dollars an hour. Students who participated were required to have a valid driver's license. Individuals who did not have a valid driver's license were excluded from the study. The study received approval from the Institutional Review Board at Old Dominion University (ODU). Students agreed to participate in the study by signing an informed consent waiver. Data were collected through a self-report questionnaire on engagement and performance measured by a program in the MAT-C System. Non-identifiable data were collected from the participants. Their information was not used for any other purpose than the study.

Apparatus & Materials

MAT-C System. The ODU Transportation department designed the MAT-C system that was used in the study. The vehicle simulator is assembled with a computer screen, steering wheel, and floor pedals. The software of MAT-C simulates driving tasks consisting of three systems: a lane tracking task, a speed task, and an observation task. The speed task requires participants to use floor pedals to sustain an optimal speed by keeping up with a bar on the screen. Lane tracking requires the participants to maintain a rectangle in the middle of the screen. Observation tasks ask the participants to press a button on the back of the steering wheel when an object appears near the simulated driving lane.

Engagement Questionnaire. On the questionnaire, participants rated their engagement of the task on a scale of 1 (*not at all)* to 7 *(completely engaged*).

Design

The study is an ANOVA within-subjects design. The four secondary tasks included: 1) texting 2) carrying on a conversation via hand-held cellphones 3) watching Tik-Tok videos and 4) mind wandering. In each task, participants completed a secondary task while operating the MAT-C program. At the end of each task, students filled out a self- report questionnaire on engagement.

Dependent Variable

The dependent variables are driving variability and engagement. A single score was used to compute driving variability of the participants by using both the steering variability and speed control. The MAT-C system calculated the average and combined it into a single score. Engagement scores were computed by the self-report questionnaire.

Procedure

At the time of arrival for testing, participants provided staff with signed consent forms. Tasks were administered to participants by a team of undergraduate and graduate research students using systematic protocols. Each of the four driving sessions were given in a randomized sequential order. Sessions were comprised of two segments. First, participants would drive in a simulator while engaging with an in-vehicle distraction following a questionnaire.

Prior to collecting data, participants practiced with the system for five minutes. Participants were able to familiarize themselves with the MAT-C system to reassure researchers that participants met the minimum driving criteria (e.g., maintaining proper speed, lane patience, and observational performance).

Participants drove the simulator four times. During each session, participants were randomly presented with one of the four secondary tasks (e.g., texting, carrying on a conversation via hand- held cellphones, searching for, and then viewing Tik-Tok Videos, and mind wandering). Participants were blind to the order of which secondary task would be presented during the sessions, until the start of the session. This was done so the participant would not demonstrate anticipatory behavior and change their driving behavior. At the conclusion of each driving session, participants would take a self-report questionnaire on engagement of the secondary task.

The four sessions lasted 10 minutes for a total of 40 minutes. Participants were instructed to drive in the same manner as they would on real roads. Participants were tested on daytime driving scenarios and asked to sustain the speed limit, vehicle control (maintain a lane), and observer for approaching objects.

Text Message Condition

During the texting conditions, participants were asked to text with a confederate researcher while driving. Trained research assistants would send open-ended messages to the participants, where the participants were instructed to reply. Typical questions used by the confederate included: *Hey! What are your plans for later today?* Or *do you want to meet up for coffee today?* At the beginning of the driving simulation, the participants phoned to hear the tone they had selected for receiving a message. The participants were instructed to answer back to the message. When the researcher received a message back, the research assistant would reply with another question, which was done to imitate real-world text interaction. The research assistant and participant would reply back and forth until the completion of the session.

TikTok Video Condition

Prior to coming into the laboratory, participants were asked to download and sign up for TikTok services and instructed to familiarize themselves with the platform. After the participant would begin driving in the simulator, a research assistant instructed the participant to begin searching for a TikTok video they liked. When the participant found a video they enjoyed, they were asked to watch the video while driving. The driver was asked to continue searching for and watching videos for the entire ten minutes.

Conversation Condition

For the conversation condition, a confederate would place a single phone call to the driving participant. The participant and assistant would carry on a conversation until the end of the session. Participants were instructed to hold the cellphone in their hand and up to their ear while driving with one hand. Research assistants were trained to converse in a natural conversation while using a script with similar questions used in the texting condition. Drivers would answer open ended questions until the 10 minutes had expired.

Mind Wandering Condition

During the mind wandering condition, drivers were instructed by a researcher to think about their plans for the week. Which included planning out all aspects of what they would cook for dinner, and when to complete household chores (e.g., laundry, dishes, cleaning the house). Participants were asked to think about each detail until the completion of the session.

Debriefing

After the conclusion of the four-driving sessions and questionnaire, participants were debriefed. The debriefing process included a discussion about the present study, a question-and-answer session, and asked about their thoughts on the study. Participants received a single monetary incentive upon the completion of the experiment. Additional brochures were provided to participants on the dangers of distracted driving and on campus counseling services.

Results

The study collected data from undergraduate students: 30 participants, 20 females, 10 males. Participants' ages ranged from 18 to 64 years old (M_{age} = 39.70, *SD* = 15.04). SPSS performed statistical analysis of the results. ANOVA within-subjects were used to determine if a significant change occurred between driving variability and task engagement on four different secondary task variables (e.g., texting, mind wandering, carrying on a conversation, and selecting a TikTok video). (See Figure 1 for mean comparisons of driving variability and engagement.) The aim of the study predicted texting while driving will have a considerable effect on driving performance (e.g., speed and steering control) than the other variables tested (e.g., talking on the phone, video searching on Tik Tok, and mind wandering).

Data were analyzed using ANOVA within-subjects to evaluate participants driving variability between four variables: texting, conversation, TikTok, and mind wandering. Mauchly's test was significant, indicating assumptions had not been violated F (3) = .526, p = .52. The ANOVA analysis revealed an interaction between driving variability and secondary task were significant, F (4,25) = 62.54, $p < .001$, $\eta_p^2 = .55$. Post-hoc analyses using Turkey's HSD with $\alpha = .05$ indicated participants in the TikTok condition (*M* = 11.47, *SD* = 4.37) had a significantly higher score than texting (*M* = 9.93, *SD* = 2.70), conversation (*M* = 4.93, *SD* = 3.04), and mind-wandering (*M* = 2.47, *SD* = 1.33) conditions (shown in Table 1). It was predicted that texting would have the greatest impact on driving variability. However, our hypothesis cannot be confirmed. Furthermore, texting while driving influenced driving variability more than the other secondary tasks; the data does not support the original hypothesis.

Data were analyzed using ANOVA within-subjects to evaluate the self-report questionnaire regarding engagement between four secondary tasks: texting, conversation, TikTok, and mind wandering. Mauchly's test was significant, indicating assumptions had not been violated F (3) = .526, p = .52. ANOVA analysis indicated level of engagement differed between a secondary task, F (4,25) = 44, p < .002, η_p^2 = .24. Post-hoc analyses using Turkey's HSD with α = .05 indicated participants in the TikTok condition (M = 6, SD = 0.79) had significantly higher scores than conversation (M = 3.83, SD = 1.17), texting (M = 3.23, SD = 1.52), and mind-wandering (M = 1.97, SD = 0.81) conditions (as depicted in Table 2). Our team hypothesized participants would rate that texting would have the highest task engagement. The data does not give support for the hypothesis.

Discussion

The purpose of the study was to identify which secondary task (e.g., texting, TikTok, mind wandering, and conversations) influenced driving variability. The second hypothesis aim was to determine participants' perception on which secondary task required more task engagement.

The purpose of the study is to determine which internal distraction requires higher task engagement and has a greater impact on driving variability. The authors hypothesized texting while driving would have a greater impact on task engagement and driving variability. Current research supported these hypotheses; however, the results of our study showed the TikTok condition had the largest influence on driving variability and task engagement.

To address the primary aim of the study, the authors predicted texting while driving would have the largest impact on driving variability (e.g., speed and steering control) than the other secondary tasks tested in the experiment. Results indicated the hypothesis was not supported by the data. The greatest impact on driving variability was viewing TikTok videos followed by texting. This may be due to TikTok requiring users to sustain visual attention to the screen while selecting and watching a video. When drivers watch TikTok videos they divert limited attention away from the primary task (driving) which affects their driving performance.

To address participants' perception of engagement on driving variability, a self-report questionnaire was administered after each task. The authors hypothesized that participants would report a higher engagement score on texting while driving. Results from the analysis did not support this hypothesis. Participants rated viewing TikTok videos had the largest impact on task engagement. TikTok content is designed to captivate its audience by attracting and holding their attention. Activities that drivers find more engaging often require more focus, thus negatively impacting driving execution compared to activities drivers find less engaging (Horrey et al., 2017). As drivers view interesting content on the platform TikTok, there is a negative impact on driving related tasks.

Driving Variability Scores

Conversation: The results demonstrated for the driving variability data, the conversation and texting and the conversation and TikTok variables were statistically significant. These results imply that participants in these conditions, texting and viewing TikTok videos had, greater driving variability than conversations. Meaning conversations on cell phones did not impact driving speed and steering control as the latter variables. However, the results demonstrated that the conversation and mind wandering findings were not statistically significant. These results imply that participants in the mind wandering condition were not different than the conversation variable.

Mind wandering: The results demonstrated for the driving variability data, the mind wandering and the texting, the mind wandering and the conversation, and the mind wandering and TikTok conditions. These results imply that the mind wandering variable affected the driving variability of the participants the least. This implies that participants in the mind wandering had a lower significant impact on performance than the remaining variables being examined (i.e., watching TikTok, texting, and conversation.)

Engagement Scores

Conversation: The results of the engagement study presented that the conversation and the TikTok conditions were statistically significantly different. These results imply that the TikTok condition required more task engagement than the conversation condition. The results show that conversation had a greater impact on the engagement of driving for the participants. Conversation and the mind wandering, and the conversation and the texting conditions did not show a significant impact on the results. Thus, concluding from the results of the study that conversation had an impact of a lower engagement score compared to the other variables (mind wandering, texting, and TikTok).

Mind Wandering: The results of the engagement study demonstrated that the mind wandering and the texting, the mind wandering and conversation, and the mind wandering and the TikTok conditions were statistically significant. The results showed that the mind wandering and the TikTok conditions had a greater impact on the engagement of driving for the participants. Meaning mind wandering scores had minimal impact on engagement scores. Thus concluding that mind wandering required the least amount of task engagement while driving. Which suggests participants were able to sustain attention to the primary task of driving while thinking about their weekly plans.

Practical Implications

Distracted driving is a rising concern for all who use the roadways. It is imperative for researchers to determine the effects of distracted driving. In addition to understanding drivers' perception of which distraction requires the most engagement, knowing which behavior effects driving at higher rates and drivers attitudes to help government agencies (i.e., NHTSA, IIHS, etc.) and driver education programs to deter their behavior. Awareness can be raised through public service announcements, lectures, interventions, and conferences. Another practical implication is to aid future experiments by researchers studying the effects of viewing TikTok while driving.

Limitations

This study was not without its limitations. The population consisted of thirty ODU undergraduate students who volunteered through the SONA system. Due to the population being so specific, there are many distinct issues that may have affected the results (e.g., education level and gender). A more diverse population would allow the study to account for many other issues, thus making the results more accurate. The study did not utilize a control group to establish a baseline in driving performance to understand the effects of secondary tasks. Controlled settings with varying road design would address real world application of the experiment. To strengthen the study there is a need to expand the setting, participation pool, and how secondary variables influence driving variability and engagement.

Future Research

Future research can transition the experiment from a simulator setting to a controlled field setting to gain insight on the effects distracted driving has on performance. In this setting, researchers have participants drive in a controlled environment while engaging in distracted behaviors. In addition, future studies can expand on emotional responses (e.g., anger or sadness) and the implication it has on driving variability or engagement. Using driving simulators to research driving performance limits participants to a controlled environment, behaving in a manner inconsistent with their natural behavior. Expanding on different internal and external secondary tasks that a driver may encounter in a real-world setting (e.g., replica of objects, radio interactions, and events) would allow participants' behaviors to occur naturally.

Conclusion

This study examined the effects of secondary tasks (e.g., texting, watching TikTok videos, conversation and mind wandering) on driving variability and engagement. The study used the MAT-C system, a vehicle simulator, that measured participants lane tracking, speed, and observation task. Participants completed a self-reporting questionnaire at the end of the simulation, rating their level of engagement. The study's findings showed watching TikTok videos and texting significantly affected driving variability and engagement. A larger and more diverse sample (e.g., age groups, genders, and/or educational factors) of participants is needed to generalize results of the study. To strengthen the study there is a need to expand the setting, participation pool, and how secondary variables influence driving variability and engagement.

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Tables

Table 1

Means and Standard Deviations for Driving Variability

Variable	*M*	*SD*
Texting	9.93	2.69
Conversation	4.93	3.04
TikTok	11.47	4.37
Mind Wandering	2.47	1.33

Note. *n* = 30.

Table 2

Means and Standard Deviations for Engagement

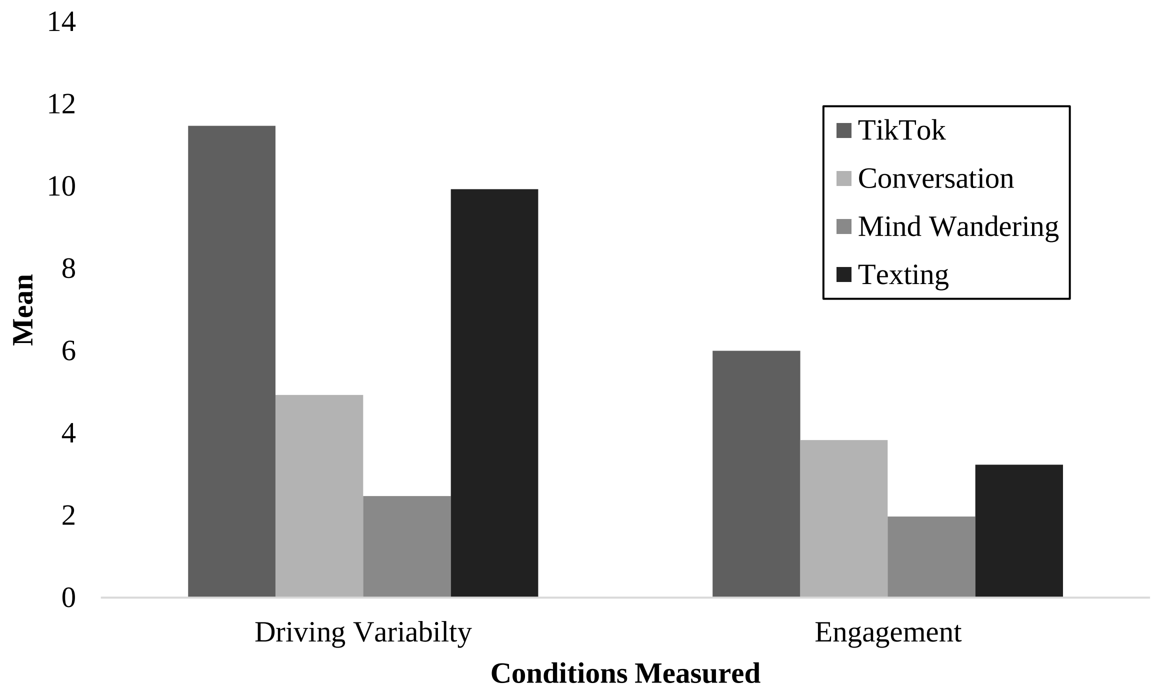
Variable	*M*	*SD*
Texting	3.23	1.52
Conversation	3.83	1.12
TikTok	6.00	0.79
Mind Wandering	1.97	0.81

Note. *n* = 30.

Figure

Figure 1

Mean Differences Across Conditions



Note. The graph depicts a comparison of mean scores on the secondary-tasks variables tested (i.e., TikTok, conversation, mind wandering, and texting) between the driving variability and task engagement conditions.